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The mildews of the cereals *

George M. Reed

In a recent paper[22] I have given a complete summary of the work that has been done on the physiological specialization of the Erysiphaceae. Since that paper was completed Salmon[29] has published some results with the hop mildew [*Sphaerotheca Humuli* (DC.) Burr.]. Salmon obtained ascospores from the hop and sowed them on the same plant, and also on *Potentilla reptans* and *Spiraea Ulmaria*, but infection occurred only on the hop. The conidia produced on the hop failed also to infect *Spiraea Ulmaria* although conidia similarly produced infected the hop.

Thus far one or more species of five genera of the Erysiphaceae have been tested with reference to their physiological specialization, namely, *Erysiphe*, *Microsphaera*, *Phyllactinia*, *Sphaerotheca*, and *Uncinula*. As yet no species of *Podosphaera* has been tested. The work with *Sphaerotheca*, *Microsphaera*, *Phyllactinia*, and *Uncinula* has been very limited, relatively few tests having been made with species of these genera. Practically all of the work of importance has been done with two species of *Erysiphe*, viz., *E. Cichoracearum* and *E. Graminis*.

Although from the morphological standpoint the same species of mildew, *Erysiphe Graminis*, attacks all grasses reported as hosts of the mildew, yet physiological differences have been found to exist between the mildews on the various grasses. Marchal[18] first pointed out the existence of *formes spéciales* in the grass mildew. He states that the mildew on each of the cereals (barley, oats,

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rye, and wheat) belongs to a separate specialized form. The mildew on wheat (*Triticum vulgare*) infected wheat and also *T. Spelta*, *T. polonicum*, and *T. turgidum*, but not *T. dicoccum*, *T. durum*, *T. monococcum*, barley, oats, or rye. The mildew on barley (*Hordeum vulgare*) infected barley and also *H. hexastichon*, *H. jubatum*, *H. murinum*, *H. nudum*, and *H. trifurcatum*, but not *H. bulbosum*, *H. maritimum*, *H. secalinum*, oats, rye, or wheat. The mildew on rye (*Secale cereale*) infected rye and *S. anatolicum*, but not the other cereals. The mildew on oats (*Avena sativa*) infected oats and also *A. fatua*, *A. orientalis*, and *Arrhenatherum elatius*, but not the other cereals.

Salmon has also done considerable work with the grass mildew, and while in general his results agree with those of Marchal, yet there are some interesting minor differences. For example, Salmon[24] was unable to infect *Arrhenatherum elatius* with the oat mildew. In the case of the barley mildew, Salmon[25] found that conidia from barley infected *Hordeum bulbosum*, *H. deficiens*, *H. distichon*, *H. hexastichon*, *H. intermedium*, *H. maritimum*, *H. vulgare*, and *H. Zeocriton*, but not *H. jubatum*, *H. murinum*, *H. secalinum*, or *H. silvaticum*.

My previous results[21] with the mildew on *Secale cereale* agree with those of Marchal. I was not able to infect barley, oats, wheat, and twelve other grasses, all of which have been reported as hosts of *Erysiphe Graminis*, while rye was readily infected with conidia from the same host.

During the past year I have carried out further extensive experiments with the mildews of barley, rye, and wheat. While at the University of Wisconsin, I had, as described in an earlier paper,[21] cultures of the rye and barley mildews growing in the botanical greenhouse. Through the kindness of Professor R. A. Harper, cultures of these mildews were forwarded to me at Columbia, Missouri. The wheat mildew was first found in the fall of 1907, at Columbia, on wheat plants brought into the greenhouse from the field for experimental work. In a few days after these plants were brought in, the mildew was observed to be present. The fungus spread very rapidly and cultures have been kept growing ever since.

I am indebted to a number of people for furnishing me with the seed of the various cereals and grasses used in the following tests. The U. S. Department of Agriculture, at Washington, D. C., sent seed of *Triticum dicoccum* (Black Winter Emmer and White Emmer), *T. durum* (var. Kubanka), *T. polonicum*, *T. Spelta*, *Hordeum distichon*, *H. nudum*, *H. vulgare*, and *H. Zeocriton*. Vilmorin-Andrieux & Company furnished seed of *Hordeum trifurcatum*, *Triticum monococcum*, and *T. turgidum*. From the California Agricultural Experiment Station I received seed of *Hordeum distichon*, *H. tetrastichon*, *Triticum dicoccum* (Black Emmer), *T. durum* (varieties Black Don, Chilean, and Kubanka), and *T. Spelta*. Haage & Schmidt, Erfurt, Germany, furnished seed of a number of plants, among others *Hordeum trifurcatum*, *Triticum monococcum*, and *T. turgidum*. Professor Trelease, of the Missouri Botanical Garden, sent me seed of *Triticum durum affine*, *T. compactum creticum*, and *T. monococcum*. Professor C. A. Zavitz, of the Ontario Agricultural College, sent seed of *Triticum dicoccum* (Red Emmer, Russian Emmer, Common Emmer, and Black Winter Emmer), and *T. durum* (Medeah Spring Wheat, Soretina Spring Wheat, and Wild Goose Spring Wheat). I am especially indebted to Professor Doctor Fr. Bubák, Director of the Botanical Garden at Tábor, Bohemia, for seed of *Triticum Freycenetii*, *T. monococcum* (varieties *Hornemannii* and *vulgare*), *T. Spelta*, *T. Thaoudar*, *T. Tumonia*, *T. turgidum*, *Secale dalmaticum*, *S. montanum*, *S. cereale* × *Triticum vulgare*, *Hordeum maritimum*, and *H. Steudelii* × *H. trifurcatum*.

According to Hackel[15] there are only three distinct species of *Triticum* in cultivation. Hackel classifies the cultivated wheats as follows:

Triticum
- *monococcum* L., Einkorn.
- *sativum*
  - *dicoccum* Schrank, Emmer.
  - *Spelta* Hackel, Spelt.
  - *tenax*
    - *vulgare* Hackel, Wheat.
    - *compactum* Hackel, Club Wheat.
    - *turgidum* Hackel, Poulard Wheat.
    - *durum* Hackel, Durum Wheat.
- *polonicum* L. Polish Wheat.

Hackel classifies the commonly cultivated barleys as follows: *Hordeum sativum distichon* Hackel, including several varieties, as *erectum*, *nutans*, *Zeocriton*, *macrolepis*, *deficiens*, and *nudum*; *H.*

sativum hexastichon Hackel; and *H. sativum vulgare* Hackel, including *H. coeleste*, *H. intermedium*, *H. Kaufmanni*, and *H. trifurcatum*.

TABLE I.—RESULTS WITH *Avena sativa* L.

Number of experiment	Date	Source of conidia	Age of plants (days)	No. of plants inoculated	No. of controls	Results		
						Date	Inoc. plants	Controls
38c	1908 Jan. 2	*Hordeum distichon*	8	3	3	1908 Jan. 11	—	—
77b	Feb. 10	" "	9	3	2	Feb. 17	—	—
79c	" 10	" "	9	2	3	" 17	—	—
80c	" 10	" "	9	3	3	" 17	—	—
86c	" 22	" "	9	5	6	" 29	—	—
13a	1907 Dec. 24	*Hordeum vulgare*	8	3	3	1907 Dec. 30	—	—
21b	" 31	" "	10	2	3	1908 Jan. 7	—	—
23b	" 31	" "	10	4	2	" 7	—	—
24b	" 31	" "	10	3	3	" 7	—	—
25c	" 31	" "	10	3	4	" 7	—	—
36b	1908 Jan. 2	" "	8	3	1	" 11	—	—
44b	" 18	" "	14	3	3	" 24	—[1]	—
45b	" 18	" "	14	3	2	" 24	—[1]	—
65c	Feb. 3	" "	10	3	2	Feb. 10	—	—
66c	" 3	" "	10	3	3	" 10	—	—
67a	" 3	" "	10	2	3	" 10	—	—
147a	Oct. 31	" "	9	3	1	Nov. 7	—	—
147c	" 31	" "	9	2	1	" 7	—	—
98b	Mar. 3	*Hordeum Zeocriton*	7	2	2	Mar. 10	—	—
99b	" 3	" "	7	3	4	" 10	—	—
100b	" 3	" "	7	2	4	" 10	—	—
101a	" 3	" "	7	2	4	" 10	—	—
58a	Feb. 1	*Triticum durum*	8	3	3	Feb. 10	—	—
93b	" 22	*Triticum polonicum*	9	5	6	" 29	—	—
94c	Mar. 3	*Triticum Spelta*	7	3	5	Mar. 10	—	—
95c	" 3	" "	7	4	2	" 10	—	—
16c	1907 Dec. 25	*Triticum vulgare*	9	3	5	1907 Dec. 30	—	—
18a	" 25	" "	9	2	4	" 30	—	—
26b	" 31	" "	10	4	2	1908 Jan. 7	—	—
27b	" 31	" "	10	3	3	" 7	—	—
32a	1908 Jan. 2	" "	8	3	5	" 11	—	—
42a	" 17	" "	13	3	4	" 24	—	—
62a	Feb. 3	" "	10	3	3	Feb. 10	—	—
76a	" 10	" "	9	3	2	" 17	—	—
90a	" 22	" "	9	5	6	" 29	—	—
92c	" 22	" "	9	4	4	" 29	—	—

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[1] Discolored areas were visible on the inoculated leaves, indicating the beginning of infection. No well-developed mycelium producing conidia appeared, however These were the only plants in which any evidence of infection was obtained.

TABLE II.— RESULTS WITH *Hordeum bulbosum* L.

Number of experiment	Date	Source of conidia	Age of plants (days)	No. of plants inoculated	No. of controls	Results		
						Date	Inoc. plants	Controls
	1908					1908		
132b	Oct. 21	*Hordeum vulgare*	8	4	2	Oct. 30	—	—
133b	“ 21	“ “	8	4	1	“ 30	—	—
137b	“ 31	“ “	9	1	0	Nov. 7	—	...
138c	“ 31	“ “	18	3[1]	1	“ 7	—	—
151a	Nov. 10	“ “	19	1[2]	1	“ 19	—	—
153b	“ 10	“ “	19	2[1]	0	“ 19	—	...
163c	“ 16	“ “	13	1	0	“ 26	—	...
164a	“ 16	“ “	13	2	1	“ 26	+[3]	—
176c	“ 27	“ “	13	1[2]	1	Dec. 5	—	—
178b	“ 27	“ “	13	2[2]	2	“ 5	—	—
179c	“ 27	“ “	13	1	0	“ 5	—	...
181a	“ 27	“ “	24	2[2]	2	“ 5	—	—

[1] The second leaf inoculated.

[2] Two leaves inoculated.

[3] A few small tufts of conidia appeared on one inoculated leaf.

In the tables given herewith, I have deemed it best to follow the older classification of Linnaeus, as the various cultivated varieties of wheat and barley are commonly referred to in this way. I have, however, indicated the position of the forms tested in Hackel's classification.

The plants used in the experiments were grown in two and one-half inch flower pots. In each pot some of the plants were inoculated, while the remaining ones were kept as controls. Generally the spores were sown on the first green leaf. After the plants were inoculated, the pots were placed under a tall bell-jar, usually three pots being placed under the same jar. The bell-jars were slightly raised at the base to allow a free circulation of air. The pots were placed in a saucer, and water, when needed, was poured into the latter.

The plants were inoculated by transferring with a scalpel conidia from an infected plant and spreading them over the surface of the leaf of the plant that was to be inoculated. In order to be sure of plenty of conidia, I found it advantageous to place infected plants under a bell-jar for a day or two before inoculation. In this way the conidia were formed in abundance and remained upon the leaves instead of being scattered by currents of air. Thus I

TABLE III. — RESULTS WITH *Hordeum distichon* L.[1]

Number of experiment	Date	Source of conidia	Age of plants (days)	No. of plants inoculated	No. of controls	Results		
						Date	Inoc. plants	Controls
5b	1907 Dec. 16	*Hordeum distichon*	9	3	4	1907 Dec. 23	+++	—
78b	1908 Feb. 10	" "	9	3	4	1908 Feb. 17	+++	—
79b	" 10	" "	9	4	2	" 17	+++	—
80a	" 10	" "	9	4	1	" 17	+++	—
86a	" 22	" "	9	5	6	" 29	+++	—
88a	" 22	" "	9	4	2	" 29	+++	—
85b	" 21	*Hordeum nudum*	8	5	5	" 29	+++	—
1a	1907 Dec. 9	*Hordeum vulgare*	8	3	3	1907 Dec. 16	+++	—
3a	" 9	" "	8	3	2	" 16	+++	—
4c	" 9	" "	8	2	3	" 16	+++	—
8c	" 16	" "	9	3	2	" 23	+++	—
9c	" 16	" "	9	1	1	" 23	+++	—
12a	" 24	" "	8	4	4	" 30	+++	—
15c	" 25	" "	9	3	2	" 30	+++	—
34b	1908 Jan. 2	" "	8	2	2	1908 Jan. 11	+++	—
35b	" 2	" "	8	2	3	" 11	+++	—
36c	" 2	" "	8	2	2	" 11	+++	—
44c	" 18	" "	14	3[2]	1	" 24	+++	—
45a	" 18	" "	14	2[2]	3	" 24	+++	—
46c	" 18	" "	14	4[2]	4	" 24	+++	—
64b	Feb. 3	" "	10	1	2	Feb. 10	+++	—
65b	" 3	" "	10	2	2	" 10	+++	—
67c	" 3	" "	10	3	3	" 10	+++	—
133a	Oct. 21	" "	8	2	1	Oct. 30	+++	—
6c	1907 Dec. 16	*Hordeum Zeocriton*	9	3	3	1907 Dec. 23	+++	—
17b	" 25	*Triticum vulgare*	9	2	3	" 30	—	—
33a	1908 Jan. 2	" "	8	3	2	1908 Jan. 11	—	—

[1] *Hordeum sativum distichon* Hackel.

[2] The second leaf of each plant inoculated.

TABLE IV.—RESULTS WITH *Hordeum jubatum* L.

Number of experiment	Date	Source of conidia	Age of plants (days)	No. of plants inoculated	No. of controls	Results		
						Date	Inoc. plants	Controls
133c	1908 Oct. 21	*Hordeum vulgare*	8	8	4	1908 Oct. 30	—	—
135c	" 23	" "	10	3	3	" 31	—	—
163a	Nov. 16	" "	13	3	1	Nov. 26	—	—
175b	" 27	" "	13	1	0	Dec. 5	—	...
180a	" 27	" "	13	1	1	" 5	—	—
181b	" 27	" "	24	1[1]	1	" 5	—	—

[1] Two leaves of the plant inoculated.

was always sure of a large quantity of good, viable conidia. In most experiments plants of the same species as that from which the mildew was obtained were inoculated. If the mildew developed upon these plants, it was considered sufficient evidence that the conidia were entirely viable.

TABLE V. — RESULTS WITH *Hordeum maritimum* With.

Number of experiment	Date	Source of conidia	Age of plants (days)	No. of plants inoculated	No. of controls	Results		
						Date	Inoc. plants	Controls
	1908					1908		
120b	July 28	*Hordeum vulgare*	4	2	1	Aug. 5	—	—
121c	" 28	" "	4	3	1	" 5	—	—
130c	Oct. 19	" "	6	5	2	Oct. 26	—	—
131c	" 19	" "	6	5	3	" 26	—	—
137c	" 31	" "	9	4	3	Nov. 7	—	—
138b	" 31	" "	9	3	1	" 7	—	—
152c	Nov. 10	" "	7	7	2	" 19	—	—
153a	" 10	" "	7	8	2	" 19	—	—
173a	" 20	" "	6	8	6	" 26	—	—
174c	" 20	" "	6	7	3	" 26	—	—
176b	" 27	" "	13	3[1]	5	Dec. 5	—	—
177c	" 27	" "	13	3[1]	3	" 5	—	—

[1] Two leaves of each plant inoculated.

TABLE VI.— RESULTS WITH *Hordeum nodosum* L.[1]

Number of experiment	Date	Source of conidia	Age of plants (days)	No. of plants inoculated	No. of controls	Results		
						Date	Inoc. plants	Controls
	1908					1908		
112c	July 10	*Hordeum vulgare*	20	2	0	July 18	+++	. . .
116b	" 18	" "	28	3[2]	0	" 28	++	. . .
132c	Oct. 21	" "	8	7	10	Oct. 30	+++	—
135b	" 23	" "	10	7	8	" 31	+++	—
151c	Nov. 10	" "	19	3	1	Nov. 19	—[3]	—
152a	" 10	" "	19	2[4]	4	" 19	—[3]	—
163b	" 16	" "	13	6	5	" 26	+++	—
164c	" 16	" "	13	10	6	" 26	+++	—
175a	" 27	" "	13	5	3	Dec. 5	++	—
177b	" 27	" "	13	4	6	" 5	+++	—
178c	" 27	" "	13	4	6	" 5	+++	—
179b	" 27	" "	13	5	2	" 5	+++	—
181c	" 27	" "	24	6[4]	6	" 5	—	—

[1] *Hordeum pratense* Huds.= *H. secalinum* Schreb.

[2] The first leaf of one plant and the second and third leaves of the other two plants were inoculated. Infection occurred on the first leaf of the one plant.

[3] The tips of the inoculated leaves had withered and turned yellow.

[4] Two leaves inoculated.

TABLE VII.—RESULTS WITH *Hordeum nudum* L.[1]

Number of experiment	Date	Source of conidia	Age of plants (days)	No. of plants inoculated	No. of controls	Results		
						Date	Inoc. plants	Controls
5a	1907 Dec. 16	*Hordeum distichon*	9	2	2	1907 Dec. 23	+++	—
38a	1908 Jan. 2	" "	8	2	2	1908 Jan. 11	+++	+[2]
78a	Feb. 10	" "	9	3	1	Feb. 17	+++	—
80b	" 10	" "	9	3	3	" 17	+++	—
86b	" 22	" "	9	3	3	" 29	+++	—
87b	" 22	" "	9	1	3	" 29	+++	—
7a	1907 Dec. 16	*Hordeum nudum*	9	2	1	1907 Dec. 23	+++	—
85a	1908 Feb. 21	" "	8	4	2	1908 Feb. 29	+++	—
1b	1907 Dec. 9	*Hordeum vulgare*	8	3	4	1907 Dec. 16	+++	—
2c	" 9	" "	8	3	3	" 16	+++	—
4a	" 9	" "	8	2	3	" 16	+++	—
8b	" 16	" "	9	2	2	" 23	+++	—
9a	" 16	" "	9	2	1	" 23	+++	—
35c	1908 Jan. 2	" "	8	3	2	1908 Jan. 11	+++	+[2]
37c	" 2	" "	8	4	3	" 11	+++	—
45c	" 18	" "	14	3	3	" 24	+++	—
48c	" 18	" "	14	1	2	" 24	+++	—
67b	Feb. 3	" "	10	1	2	Feb. 10	+++	—
68a	" 3	" "	10	1	0	" 10	+++	.....
61b	" 1	*Triticum polonicum*	7	1	1	" 10	—	—
43c	Jan. 17	*Triticum vulgare*	13	2	3	Jan. 24	—	+[2]

[1] Hackel considers this a variety of *Hordeum sativum distichon.*

[2] A small patch of mycelium bearing conidia on one leaf of a control.

TABLE VIII. — RESULTS WITH *Hordeum Steudelii* ♀ × *H. trifurcatum* ♂

Number of experiment	Date	Source of conidia	Age of plants (days)	No. of plants inoculated	No. of controls	Results		
						Date	Inoc. plants	Controls
120a	1908 July 28	*Hordeum vulgare*	4	3	1	1908 Aug. 5	+++	—
121b	" 28	" "	4	3	2	" 5	+++	—
131b	Oct. 19	" "	6	3	3	Oct. 26	+++	—
172b	Nov. 20	" "	6	2	1	Nov. 26	+++	—
173c	" 20	" "	6	2	3	" 26	+++	—
174b	" 20	" "	6	3	3	" 26	+++	—
177a	" 27	" "	6	4	3	Dec. 5	+++	—
179a	" 27	" "	6	3	2	" 5	+++	—
180c	" 27	" "	6	3	1	" 5	+++	—

TABLE IX.— RESULTS WITH *Hordeum tetrastichon* L.[1]

Number of experiment	Date	Source of conidia	Age of plants ys)	No. of plants inoculated	No of controls	Results		
						Date	Inoc. plants	Controls
	1908					1908		
130b	Oct. 19	*Hordeum vulgare*	6	3	2	Oct. 26	+++	—
172a	Nov. 20	" "	6	3	2	Nov. 26	+++	—
173b	" 20	" "	6	3	6	" 26	+++	—
174a	" 20	" "	6	2	1	" 26	+++	—
175c	" 27	" "	6	3	4	Dec. 5	+++	—
178a	" 27	" "	6	5	4	" 5	+++	—
180b	" 27	" "	6	7	2	" 5	+++	—

[1] Variety *trifurcatum* Schl. used.

TABLE X. — RESULTS WITH *Hordeum trifurcatum* Jacq.[1]

Number of experiment	Date	Source of conidia	Age of plants (days)	No. of plants inoculated	No. of controls	Results		
						Date	Inoc. plants	Controls
	1908					1908		
115a	July 14	*Hordeum vulgare*	4	4	2	July 22	+++	—
115b	" 14	" "	4	3	3	" 22	+++	—
119b	" 23	" "	6	3	1	" 29	+++	—
151b	Nov. 10	" "	7	1	0	Nov. 19	+++	....
164b	" 16	" "	13	2[2]	1	" 26	+++	—

[1] Considered by Hackel to be a form of *Hordeum sativum vulgare*.

[2] Two leaves of each plant inoculated.

The infection, if it occurred, was observed in three to five days after inoculation. A number of observations were made, but only the final one is recorded.

In the accompanying tables I have brought together the results of the tests. I have indicated a full, vigorous growth of mildew by three plus signs, a good infection by two plus signs, a slight infection by one plus sign, and no infection by the minus sign.

For the purpose of direct comparison, I have brought together in TABLE XXVIII all of the results given with these twenty-seven different grasses. I have also included my[21] own previous results with the grass mildew and also the results obtained by Marchal[18] and Salmon[24, 25, 27].

Marchal does not give the data upon which his conclusions are based. It is impossible to tell whether he sowed spores from

TABLE XI.—RESULTS WITH *Hordeum vulgare* L.[1]

Number of experiment	Date	Source of conidia	Age of plants (days)	No. of plants inoculated	No. of controls	Results		
						Date	Inoc. plants	Controls
5c	1907 Dec. 16	*Hordeum distichon*	9	3	2	1907 Dec. 23	+++	—
38b	1908 Jan. 2	“ “	9	3	4	1908 Jan. 11	+++	—
77a	Feb. 10	“ “	9	4	4	Feb. 17	+++	—
192a	Nov. 30	*Hordeum nodosum*	9	1	2	Dec. 5	+++	—
7c	1907 Dec. 16	*Hordeum nudum*	9	4	3	1907 Dec. 23	+++	+[2]
1c	“ 9	*Hordeum vulgare*	8	4	4	“ 16	+++	—
2b	“ 9	“ “	8	3	3	“ 16	+++	—
3b	“ 9	“ “	8	2	2	“ 16	+++	—
9d	“ 16	“ “	9	4	3	“ 23	+++	—
10a	“ 24	“ “	10	2	4	“ 30	+++	—
11b	“ 24	“ “	10	4	2	“ 30	+++	—
12b	“ 24	“ “	10	3	3	“ 30	+++	—
13c	“ 24	“ “	10	4	4	“ 30	+++	—
14b	“ 25	“ “	9	4	3	“ 30	+++	—
14c	“ 25	“ “	9	3	3	“ 30	+++	—
15a	“ 25	“ “	11	3	2	“ 30	+++	—
20b	“ 31	“ “	10	3	3	1908 Jan. 7	+++	—
22c	“ 31	“ “	10	3	2	“ 7	+++	—
24c	“ 31	“ “	10	2	3	“ 7	+++	—
25b	“ 31	“ “	10	3	2	“ 7	+++	—
37b	1908 Jan. 2	“ “	8	2	3	“ 11	+++	+[2]
44a	“ 18	“ “	14	2	3	“ 24	+++	—
46b	“ 18	“ “	14	1	1	“ 24	+++	—
47b	“ 18	“ “	14	1	2	“ 24	+++	—
64a	Feb. 3	“ “	10	2	3	Feb. 10	+++	—
66a	“ 3	“ “	10	2	1	“ 10	+++	—
111c	July 10	“ “	7	5	5	July 18	+++	—
112a	“ 10	“ “	7	2	5	“ 18	+++	—
115c	“ 14	“ “	4	4	3	“ 22	+++	—
116a	“ 18	“ “	8	2[3]	2	“ 28	+++	—
119a	“ 23	“ “	6	4	3	“ 29	+++	—
120c	“ 28	“ “	4	4	2	Aug. 5	+++	—
121a	“ 28	“ “	4	5	3	“ 5	+++	—
130a	Oct. 19	“ “	6	3	3	Oct. 26	+++	+[2]
131a	“ 19	“ “	6	4	2	“ 26	+++	—
132a	“ 21	“ “	8	3	1	“ 30	+++	—
135a	“ 23	“ “	4	3	6	“ 31	+++	—
137a	“ 31	“ “	9	2	1	Nov. 7	+++	—
138a	“ 31	“ “	9	3	1	“ 7	+++	—
147b	“ 31	“ “	9	2	2	“ 7	+++	—
152b	Nov. 10	“ “	7	5	3	“ 19	+++	—
153c	“ 10	“ “	7	4	3	“ 19	+++	—
172c	“ 20	“ “	6	4	2	“ 26	+++	—
176a	“ 27	“ “	6	6	7	Dec. 5	+++	—
6b	1907 Dec. 16	*Hordeum Zeocriton*	9	3	3	1907 Dec. 23	+++	—
98c	1908 Mar. 3	“ “	7	3	2	1908 Mar. 10	+++	—

TABLE XI.—RESULTS WITH *Hordeum vulgare* L.[1]—*Continued*

Number of experiment	Date	Source of conidia	Age of plants (days)	No. of plants inoculated	No. of controls	Results Date	Results Inoc. plants	Results Controls
99c	1908 Mar. 3	*Hordeum Zeocriton*	7	2	1	1908 Mar. 10	+++	—
100c	" 3	" "	7	2	1	" 10	+++	—
101c	" 3	" "	7	3	3	" 10	+++	—
39c	Jan. 17	*Triticum dicoccum*	13	3	2	Jan. 24	—	—
40c	" 17	" "	13	2	3	" 24	—	—
59b	Feb. 1	*Triticum durum*	8	2	3	Feb. 10	—	—
60a	" 1	*Triticum polonicum*	8	2	2	" 10	—	—
94a	Mar. 3	*Triticum Spelta*	7	1	1	Mar. 10	—	—
16b	1907 Dec. 25	*Triticum vulgare*	11	2	2	1907 Dec. 30	—	—
18c	" 25	" "	11	4	4	" 30	—	—
19c	" 25	" "	9	2	3	" 30	—	—
27a	" 31	" "	10	3	3	1908 Jan. 7	—	—
28a	" 31	" "	10	4	3	" 7	—	—
29c	" 31	" "	6	3	4	" 7	—	—
30c	1908 Jan. 2	" "	8	4	2	" 11	—	—
32b	" 2	" "	8	3	2	" 11	—	—
33b	" 2	" "	8	3	2	" 11	—	—
41c	" 17	" "	13	2	3	" 24	—	—
63c	Feb. 3	" "	10	1	1	Feb. 10	—	—
75a	" 10	" "	9	4	3	" 17	—	+[2]
96c	Mar. 3	" "	7	2	4	Mar. 10	—	—

[1] *Hordeum sativum vulgare* Hackel.

[2] A small infected area appeared on one control.

[3] The second green leaf of each plant inoculated.

each of the cereals on the various grasses. Consequently I have merely indicated whether his results are negative or positive. I have indicated his results simply on the basis of his seven *formes spéciales*.

In this table the first figure indicates the number of tests, the second figure the number of plants or leaves inoculated, and the third figure the number that became infected.

It is plain, from a consideration of TABLE I, and also the general summary, that the oat (*Avena sativa*) is immune to the barley, rye, and wheat mildews. In no case did complete infection follow where conidia were used from any of these three cereals. If, however, conidia are taken from *A. sativa* and sown upon the same plant, full infection follows, as shown by both Marchal's and Salmon's results.

TABLE XII.—RESULTS WITH *Hordeum Zeocriton* L.[1]

Number of experiment	Date	Source of conidia	Age of plants (days)	No. of plants inoculated	No. of controls	Results		
						Date	Inoc. plants	Controls
77c	1908 Feb. 10	*Hordeum distichon*	9	4	3	1908 Feb. 17	+++	—
79a	" 10	" "	9	4	2	" 17	+++	—
87a	" 22	" "	9	3	2	" 29	+++	—
88c	" 22	" "	9	5	3	" 29	+++	—
7b	1907 Dec. 16	*Hordeum nudum*	9	3	5	1907 Dec. 23	+++	—
85c	1908 Feb. 21	" "	8	4	5	1908 Feb. 29	+++	—
2a	1907 Dec. 9	*Hordeum vulgare*	8	2	4	1907 Dec. 16	+++	—
3c	" 9	" "	8	4	4	" 16	+++	—
4b	" 9	" "	8	2	4	" 16	+++	—
8a	" 16	" "	9	3	3	" 23	+++	+[2]
9b	" 16	" "	9	2	2	" 23	+++	—
20c	" 31	" "	10	3	2	1908 Jan. 7	+++	—
21a	" 31	" "	10	3	2	" 7	+++	—
22a	" 31	" "	10	2	2	" 7	+++	—
23a	" 31	" "	10	2	2	" 7	+++	—
24a	" 31	" "	10	2	2	" 7	+++	—
25a	" 31	" "	10	3	3	" 7	+++	—
47a	1908 Jan. 18	" "	14	3	3	" 24	+++	+[2]
48b	" 18	" "	14	2[3]	3	" 24	+++	—
65a	Feb. 3	" "	10	2	1	Feb. 10	+++	—
68b	" 3	" "	10	1	1	" 10	+++	—
68c	" 3	" "	10	1	2	" 10	+++	—
6a	1907 Dec. 16	*Hordeum Zeocriton*	9	3	2	1907 Dec. 23	+++	—
42b	1908 Jan. 17	*Triticum vulgare*	13	3[3]	3	1908 Jan. 24	—	—

[1] Considered by Hackel to be a form of *Hordeum sativum distichon*.

[2] A small infected area on two of the control plants.

[3] The second green leaf of each plant inoculated.

It is to be noted that in two of my experiments (44*b* and 45*b*, TABLE I), the leaves inoculated with barley mildew showed marked discolored areas. These areas were observed closely from time to time. There was strong evidence of an incipient infection, but the fungus failed to reach a full development. It is interesting in this connection to recall some of Salmon's[28] experiments. Salmon has studied the stages of development reached by the mildew from wheat when sown on barley, a plant which the wheat mildew cannot fully infect. He has found that the conidia germinate and form tubes which develop haustoria. There was, however, no marked development of the mycelium.

TABLE XIII. — RESULTS WITH *Secale cereale* L.

Number of experiment	Date	Source of conidia	Age of plants (days)	No. of plants inoculated	No. of controls	Results		
						Date	Inoc. plants	Controls
78c	1908 Feb. 10	*Hordeum distichon*	9	3	1	1908 Feb. 17	—	—
87c	Feb. 22	" "	9	2	3	" 29	—	—
88b	" 22	" "	9	2	3	" 29	—	—
13b	1907 Dec. 24	*Hordeum vulgare*	8	3	1	1907 Dec. 30	—	—
21c	" 31	" "	10	2	1	1908 Jan. 7	—	—
23c	" 31	" "	10	3	3	" 7	—	—
34c	1908 Jan. 2	" "	8	2	2	" 11	—	—
35a	" 2	" "	8	3	1	" 11	—	—
46a	" 18	" "	14	1	2	" 24	—	—
48a	" 18	" "	14	2	2	" 24	—	—
66b	Feb. 3	" "	10	1	1	Feb. 10	—	—
136a	Oct. 23	*Secale cereale*	4	2	1	Oct. 31	+++	—
158c	Nov. 10	" "	7	4	1	Nov. 19	+++	—
159a	" 10	" "	7	1	0	" 19	+++	...
170c	" 20	" "	17	2[1]	2	" 26	+++	—
171c	" 20	" "	6	3	1	" 26	+++	—
187c	" 27	" "	6	1	0	Dec. 5	+++	...
83a	Feb. 21	*Triticum durum*	8	3	2	Feb. 29	—	—
17a	1907 Dec. 25	*Triticum vulgare*	9	3	2	1907 Dec. 30	—	—
19a	" 25	" "	9	2	3	" 30	—	—
26c	" 31	" "	10	3	1	1908 Jan. 7	—	—
28b	" 31	" "	10	2	1	" 7	—	—
29a	" 31	" "	10	3	2	" 7	—	—
31a	1908 Jan. 2	" "	8	2	2	Jan. 11	—	—
41b	" 17	" "	13	2	1	" 24	—	—
76b	Feb. 10	" "	9	2	1	Feb. 17	—	—
91c	" 22	" "	9	3	2	" 29	—	—

[1] The first leaf of one plant and the second leaf of the other inoculated.

TABLE XIV. — RESULTS WITH *Secale dalmaticum* Vis.

Number of experiment	Date	Source of conidia	Age of plants (days)	No. of plants inoculated	No. of controls	Results		
						Date	Inoc. Plants	Controls
158b	1908 Nov. 10	*Secale cereale*	7	1	0	1908 Nov. 19	—	....
171b	" 20	" "	17	1[1]	0	" 26	—	....
186a	" 27	" "	24	1[2]	0	Dec. 5	—	....

[1] The first and second leaves inoculated.

[2] The second and third leaves inoculated.

TABLE XV. — RESULTS WITH *Secale montanum* Guss.

Number of experiment	Date	Source of conidia	Age of plants (days)	No. of plants inoculated	No. of controls	Results		
						Date	Inoc. plants	Controls
	1908					1908		
146c	Oct. 31	*Secale cereale*	12	1	0	Nov. 7	—	.....
159b	Nov. 10	" "	22	1[1]	1	" 19	—	—
170a	" 20	" "	17	2[2]	1	" 26	—	—
186b	" 27	" "	13	1[2]	0	Dec. 5	+++	.....
187a	" 27	" "	24	2[2]	2	" 5	—	—
199a	Dec. 14	" "	23	3	0	" 23	—	.....
199b	" 14	" "	30	1	0	" 23	+++	.....
199c	" 14	" "	23	1	0	" 23	+++	.....

[1] The first and third leaves inoculated.

[2] Two leaves of each plant inoculated.

Out of the eleven species of *Hordeum* tested with the barley mildew, seven (*Hordeum distichon*, *H. nudum*, *H. Steudelii* x *H. trifurcatum*, *H. tetrastichon*, *H. trifurcatum*, *H. vulgare*, and *H. Zeocriton*) proved perfectly susceptible. Infection occurred on every plant that was inoculated.

One species (*Hordeum nodosum*) gave a very large percentage of infection, fifty-one plants out of the sixty-four inoculated becoming infected. According to the Index Kewensis, this species is the same as *Hordeum secalinum* Schreb. Salmon[25] claims that *H. secalinum* is entirely immune to the barley mildew. I am uncertain whether Salmon was working with *H. secalinum* Schreb. or whether he had some other species of *Hordeum* listed under this specific name. It is clear from my results that young plants of *Hordeum nodosum* are quite susceptible to the barley mildew. Older plants, however, appear to be immune, for in every case where the second green leaf was inoculated, no infection occurred.

When plants of *Hordeum bulbosum* were inoculated with conidia from barley, only one leaf out of the twenty-four inoculated became infected. It is interesting to note that Salmon secured only one positive result out of fourteen inoculated plants, and Marchal reported the results with this plant as negative, when conidia from barley were used. This species evidently is practically immune to the barley mildew.

In my experiments I was unable to infect *Hordeum jubatum* with the barley mildew. This result is in harmony with the work of Salmon. Marchal, however, states that *H. jubatum* can be infected with conidia from the barley.

My results with *Hordeum maritimum* agree with Marchal's. I was unable to obtain any infection if conidia from barley were

TABLE XVI. — RESULTS WITH *Secale cereale* L. × *Triticum vulgare* Vill.[1]

Number of experiment	Date	Source of conidia	Age of plants (days)	No. of plants inoculated	No. of controls	Results		
						Date	Inoc. plants	Controls
127d	1908 Oct. 19	*Secale cereale*	6	1	1[2]	1908 Oct. 26	—	—
136b	“ 23	“ “	4	1	0	“ 31	—	.....
146a	“ 31	“ “	12	1[3]	0	Nov. 7	+[4]	.....
146b	“ 31	“ “	12	1[3]	0	“ 7	+[4]	.....
158a	Nov. 10	“ “	7	1	0	“ 19	+[4]	.....
162d	“ 12	“ “	9	1	1[2]	“ 21	++[5]	—
170b	“ 20	“ “	6	1	0	“ 26	—	.....
171a	“ 20	“ “	17	2[6]	1	“ 26	++	—
186c	“ 27	“ “	13	2	0	Dec. 5	++[7]	.....
187b	“ 27	“ “	13	1[8]	0	“ 5	++[9]	.....
196b	Dec. 14	“ “	30	2[10]	0	“ 23	—	.....
197b	“ 14	“ “	30	2	0	“ 23	++[11]	.....
198b	“ 14	“ “	30	2	0	“ 23	—	.....
122c	July 28	*Triticum vulgare*	4	2	1	Aug. 5	—	—
126a	“ 28	“ “	4	2	1	“ 5	—	—
127c	Oct. 19	“ “	6	1	1	Oct. 26	—	—
145c	“ 31	“ “	18	1[12]	1	Nov. 7	—	—
162c	Nov. 12	“ “	9	1	1	“ 21	—	—
168b	“ 20	“ “	6	2	0	“ 26	+[13]	.....
185b	“ 26	“ “	12	1[8]	0	Dec. 5	—	.....
196a	Dec. 14	“ “	30	2	0	“ 23	—	.....
197a	“ 14	“ “	30	2	0	“ 23	—	.....
198a	“ 14	“ “	30	2	0	“ 23	—	.....

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[1] The seed for these experiments was obtained from Professor Bubák, Director of the Botanical Garden, Tábor, Bohemia.

[2] The control plant was inoculated with conidia from wheat but no infection occurred. (See exp. 127c and 162c.)

[3] The second leaf inoculated.

[4] Slight discolored areas appeared on the inoculated parts.

[5] A good infection, conidia being produced.

[6] Two leaves inoculated.

[7] A good infection of one leaf, and the lower leaf sheaths of one plant.

[8] Three leaves inoculated.

[9] A fair infection of one leaf.

[10] The second leaf of one plant and the fourth leaf of the other inoculated.

[11] A good infection of one leaf.

[12] The second and third leaves inoculated.

[13] A small infected area appeared on one leaf.

TABLE XVII. — RESULTS WITH *Triticum compactum* Host[1]

Number of experiment	Date	Source of conidia	Age of plants (days)	No. of plants inoculated	No. of controls	Results		
						Date	Inoc. plants	Controls
	1908					1908		
105b	June 24	*Triticum vulgare*	4	2	1	June 30	+++	—
106c	" 24	" "	4	2	0	" 30	+++	....
107b	" 24	" "	4	2	2	" 30	+++	—
108b	July 7	" "	6	1	1	July 14	+++	—
109c	" 7	" "	6	4	2	" 14	+++	—
110a	" 7	" "	6	4	3	" 14	+++	—
118a	" 22	" "	5	2	2	" 29	+++	—
139a	Oct. 31	" "	7	5	3	Nov. 7	+++	—
144a	" 31	" "	7	10	4	" 7	+++	—

[1] *Triticum sativum compactum* Hackel. The variety *creticum* was used in all the tests.

sown on seedlings of this plant. Altogether twelve tests were made, fifty-eight plants being inoculated. Salmon, however, states that three plants out of twelve inoculated became infected. The species shows a marked resistance to the barley mildew, even though it may not be entirely immune.

When rye (*Secale cereale*) was inoculated with the barley or wheat mildew, no infection occurred. This was clearly shown through the large number of tests made. If, however, rye plants were inoculated with rye mildew, full and complete infection took place. Furthermore, the mildew on rye was capable, according to Marchal, of infecting *Secale anatolicum*. I have found that three plants of *S. montanum* out of twelve inoculated became infected. In these successful infections there was a very vigorous growth of mildew. In the three attempts made with *Secale dalmaticum* no infection occurred.

Conidia from wheat (*Triticum vulgare*) failed to infect any of the other cereals. Conidia from this same host, however, produced full and complete infection upon all of the eleven species of *Triticum* tested. Every plant of *Triticum compactum*, *T. durum* (six varieties), *T. Freycenetii*, *T. polonicum*, *T. Spelta*, *T. Thaoudar*, *T. Tumonia*, *T. turgidum*, and *T. vulgare* which were inoculated with conidia from wheat, became infected.

Fifty-seven leaves of *Triticum monococcum* were inoculated and forty-seven of these became infected. In most cases a good, vigorous growth of mildew was present.

TABLE XVIII. — RESULTS WITH *Triticum dicoccum* Schrank[1]

Number of experiment	Date	Source of conidia	Age of plants (days)	No. of plants inoculated	No. of controls	Results		
						Date	Inoc. plants	Controls
	1908					1908		
34a[2]	Jan. 2	*Hordeum vulgare*	8	4	4	Jan. 11	—	—
111b[2]	July 10	" "	7	3	2	July 18	—	—
99a[2]	Mar. 3	*Hordeum Zeocriton*	7	2	1	Mar. 10	—	—
39a[2]	Jan. 17	*Triticum dicoccum*	13	2	3	Jan. 24	+++	—
40b[2]	" 17	" "	13	3	4	" 24	+++	—
60c[2]	Feb. 1	*Triticum polonicum*	8	2	1	Feb. 10	+++	—
74c[2]	" 10	" "	9	3	3	" 17	+++	—
93c[2]	" 22	" "	9	2	2	" 29	+++	—
56b[2]	" 1	*Triticum Spelta*	8	1	3	" 10	+++	—
69a[2]	" 10	" "	9	3	3	" 17	+++	—
70a[2]	" 10	" "	9	3	2	" 17	+++	—
94b[2]	Mar. 3	" "	7	3	1	Mar. 10	+++	—
95a[2]	" 3	" "	7	3	4	" 10	+++	—
30a[2]	Jan. 2	*Triticum vulgare*	8	4	3	Jan. 11	+++	—
31b[2]	" 2	" "	8	2	3	" 11	+++	—
43a[2]	" 17	" "	13	4	4	" 24	+++	—
50c[2]	" 24	" "	10	4	2	" 30	+++	—
55a[2]	" 24	" "	10	3	2	" 30	+++	—
62b[2]	Feb. 3	" "	10	2	0	Feb. 10	+++	....
89c[2]	" 22	" "	9	3	2	" 29	+++	—
91b[2]	" 22	" "	9	3	3	" 29	+++	—
96b[2]	Mar. 3	" "	7	3	1	Mar. 10	+++	—
97a[2]	" 3	" "	7	3	2	" 10	+++	—
149c[2]	Nov. 2	" "	9	4	2	Nov. 7	+++	—
150b[2]	" 2	" "	9	5	3	" 7	+++	—
184a[2]	" 27	" "	6	8	8	Dec. 5	+++	—
193c[2]	Dec. 14	" "	24	2[3]	2	" 20	+++	+[4]
156a[5]	Nov. 10	" "	7	4	4	Nov. 19	+++	—
157b[5]	" 10	" "	7	4	3	" 19	+++	—
166b[5]	" 20	" "	6	9	9	" 26	+++	—
169b[5]	" 20	" "	6	6	1	" 26	+++	—
182c[5]	" 27	" "	6	9	7	Dec. 5	+++	—
193b[5]	Dec. 14	" "	24	3[3]	2	" 20	+	—
155c[6]	Nov. 10	" "	7	5	4	Nov. 19	—	—
161b[6]	" 12	" "	9	5	4	" 21	—	—
165b[6]	" 20	" "	6	8	3	" 26	—	—
167c[6]	" 20	" "	6	7	4	" 26	—	—
182a[6]	" 27	" "	6	8	6	Dec. 5	—	—
183b[6]	" 27	" "	6	4	2	" 5	++	—
184c[6]	" 27	" "	6	7	7	" 5	—	
154b[7]	" 10	" "	7	5[8]	3	Nov. 19	+	—
155b[7]	" 10	" "	7	4	7	" 19	—	—
166c[7]	" 20	" "	6	4	7	" 26	—	—
169a[7]	" 20	" "	6	5	6	" 26	—	—
183c[7]	" 27	" "	6	8	4	Dec. 5	—	—
193a[7]	Dec. 14	" "	24	2[3]	2	" 20	—	—
64c[9]	Feb. 3	*Hordeum vulgare*	10	4	8	Feb. 10	—	—
71c[9]	" 10	*Triticum dicoccum*	9	3	2	" 17	+[10]	—
72a[9]	" 10	" "	9	3	2	" 17	—	—
83c[9]	" 21	*Triticum durum*	8	4	6	" 29	—	—
84c[9]	" 21	" "	8	3	3	" 29	—	—
56a[9]	" 1	*Triticum Spelta*	8	3	6	" 10	—	—

TABLE XVIII. — RESULTS WITH *Triticum dicoccum* Schrank.[1]— *Continued*

Number of experiment	Date	Source of conidia	Age of plants (days)	No. of plants inoculated	No. of controls	Results		
						Date	Inoc. plants	Controls
	1908					1908		
57b[9]	Feb. 1	*Triticum Spelta*	8	4	5	Feb. 10	—	—
69c[9]	" 10	" "	9	2	3	" 17	+[10]	—
95b[9]	Mar. 3	" "	7	3	3	Mar. 10	—	—
49b[9]	Jan. 24	*Triticum vulgare*	10	4	2	Jan. 30	—	—
50b[9]	" 24	" "	10	3	2	" 30	—	—
54a[9]	" 24	" "	10	3	3	" 30	—	—
89b[9]	Feb. 22	" "	9	4	4	Feb. 29	—	—
90b[9]	" 22	" "	9	3	3	" 29	—	—
96a[9]	Mar. 3	" "	7	3	3	Mar. 10	—	—
97b[9]	" 3	" "	7	3	3	" 10	—	—
103c[9]	May 16	" "	10	2	1	May 24	++[11]	—
104c[9]	" 30	" "	6	2	3	June 10	—	—
108c[9]	July 7	" "	4	3	2	July 14	—	—
143a[9]	Oct. 31	" "	7	5	9	Nov. 7	—	—
165a[9]	Nov. 20	" "	6	5	5	" 26	—	—
185c[9]	" 27	" "	13	2[12]	1	Dec. 5	—	—

[1] *Triticum sativum dicoccum* Hackel.

[2] Black Winter Emmer.

[3] Two leaves of each plant inoculated.

[4] A slight infection of one control plant.

[5] Red Emmer.

[6] Common Emmer.

[7] Russian Emmer.

[8] One seedling had a different appearance from the others and was well infected with the mildew. Evidently the seedling was not a plant of Russian Emmer.

[9] White Emmer.

[10] Slight discolored areas were present on one of the inoculated leaves.

[11] A good infection of one leaf of one plant, the mildew appearing on the leaf-sheath and the lower portion of the blade.

[12] The second leaf and sheath of each plant inoculated.

Five varieties of Emmer (*Triticum dicoccum*) were tested with the wheat mildew. As seen from the table, two varieties (Black Emmer and Red Emmer) were entirely susceptible to the mildew. Every plant inoculated became infected, and the growth of the fungus was as vigorous as ever appeared upon wheat. The other three varieties (White Emmer, Common Emmer, and Russian Emmer) proved quite resistant to the mildew. Out of forty-four leaves of Common Emmer inoculated, four showed infection. Out of sixty-seven leaves of White Emmer inoculated, three became infected ; and none of the twenty-seven plants of Russian Emmer

TABLE XIX. — RESULTS WITH *Triticum durum* Desf.[1]

Number of experiment	Date	Source of conidia	Age of plants (days)	No. of plants inoculated	No. of controls	Results		
						Date	Inoc. plants	Controls
	1908					1908		
111a[2]	July 10	*Hordeum vulgare*	7	3	5	July 18	—	—
58b[2]	Feb. 1	*Triticum durum*	8	1	0	Feb. 10	+++	....
84a[2]	" 21	" "	8	3	2	" 29	+++	—
73b[2]	" 10	*Triticum polonicum*	9	2	1	" 17	+++	—
74a[2]	" 10	" "	9	2	1	" 17	+++	—
93a[2]	" 22	" "	9	1	1	" 29	+++	—
70b[2]	" 10	*Triticum Spelta*	9	3	1	" 17	+++	—
51b[2]	Jan. 24	*Triticum vulgare*	10	2	2	Jan. 30	+++	—
52a[2]	" 24	" "	10	1	1	" 30	+++	—
53a[2]	" 24	" "	10	3	1	" 30	+++	—
63a[2]	Feb. 3	" "	10	1	1	Feb. 10	+++	—
91a[2]	" 22	" "	9	2	3	" 29	+++	—
139b[3]	Oct. 31	" "	7	5	4	Nov. 7	+++	—
140a[3]	" 31	" "	7	4	5	" 7	+++	—
140b[4]	" 31	" "	7	3	2	" 7	+++	—
142b[4]	" 31	" "	7	3	4	" 7	+++	—
140c[5]	" 31	" "	7	4	2	" 7	+++	—
144b[5]	" 31	" "	7	5	1	" 7	+++	—
141a[6]	" 31	" "	7	2	3	" 7	+++	—
149b[6]	Nov. 2	" "	9	1	0	" 7	+++	....
141c[7]	Oct. 31	" "	7	2	2	" 7	+++	—
149a[7]	Nov. 2	" "	9	2	1	" 7	+++	—
144c[8]	Oct. 31	" "	7	4	3	" 7	+++	—
150c[8]	Nov. 2	" "	9	3	3	" 7	+++	—
156c[9]	" 10	" "	7	3	4	" 19	+++	—
161c[9]	" 12	" "	9	3	2	" 21	+++	—

[1] *Triticum sativum durum* Hackel.

[2] Var. Kubanka.

[3] Var. Black Don.

[4] Var. Medeah.

[5] Var. Chilean.

[6] Var. *affine*.

[7] Var. Wild Goose.

[8] Var. Velvet Don.

[9] Var. Soretina Spring Wheat

TABLE XX. — RESULTS WITH *Triticum Freycenetii* Hort.

Number of experiment	Date	Source of conidia	Age of plants (days)	No. of plants inoculated	No. of controls	Results		
						Date	Inoc. plants	Controls
	1908					1908		
122b	July 28	*Triticum vulgare*	4	6	4	Aug. 5	++	—
123a	" 28	" "	4	6	2	" 5	++	—
128a	Oct. 19	" "	6	3	3	Oct. 26	+++	—
129c	" 19	" "	6	5	2	" 26	+++	—
166a	Nov. 20	" "	6	5	1	Nov. 26	+++	—
167b	" 20	" "	6	3	2	" 26	+++	—
182b	" 27	" "	6	2	3	Dec. 5	++	—
184b	" 27	" "	6	4	4	" 5	+++	—

TABLE XXI. — RESULTS WITH *Triticum monococcum* L.

Number of experiment	Date	Source of conidia	Age of plants (days)	No. of plants inoculated	No. of controls	Results		
						Date	Inoc. plants	Controls
	1908					1908		
114c[1]	July 14	*Triticum compactum*	4	2	1	July 22	++	—
102b[2]	May 16	*Triticum vulgare*	10	1	0	May 24	—	....
104b[2]	" 30	" "	24	1[3]	0	June 10	—	....
105c[2]	June 24	" "	4	1	0	" 30	+	....
106b[2]	" 24	" "	4	2	1	" 30	++	—
107c[2]	" 24	" "	4	1	0	" 30	+++	....
108a[2]	July 7	" "	7	1	1	July 14	—	—
109a[2]	" 7	" "	7	2	1	" 14	—	—
110b[2]	" 7	" "	7	2	1	" 14	+++	—
117c[1]	" 22	" "	5	3	2	" 29	+++	—
118b[1]	" 22	" "	5	3	1	" 29	+++	—
123c[4]	" 28	" "	4	2	1	Aug. 5	+++	—
129b[4]	Oct. 19	" "	6	4	1	Oct. 26	++	—
143c[4]	" 31	" "	7	5	4	Nov. 7	+++	—
150a[4]	Nov. 2	" "	9	2	1	" 7	+++	—
156b[4]	" 10	" "	7	3	4	" 19	—	—
162b[4]	" 12	" "	9	3	2	" 21	++	—
125c[5]	July 28	" "	4	3	3	Aug. 5	+++	—
128b[5]	Oct. 19	" "	6	3	4	Oct. 26	++[6]	—
142c[5]	" 31	" "	7	3	2	Nov. 7	++	—
145b[5]	" 31	" "	7	3	3	" 7	+++	—
157c[5]	Nov. 10	" "	7	3	1	" 19	+++	—
160b[5]	" 12	" "	9	4	1	" 20	++	—

[1] Seed obtained from Vilmorin-Andrieux Co., of Paris.

[2] Seed obtained from Dr. Wm. Trelease.

[3] Two leaves inoculated.

[4] Variety *Hornemanni*.

[5] Variety *vulgare*. Varieties *Hornemanni* and *vulgare* were obtained from the Botanical Garden at Tábor, Bohemia.

[6] A very good infection of one leaf.

became infected. There is, therefore, a marked difference in susceptibility of these five varieties. It is to be noted here, that Marchal obtained negative results when he sowed conidia from wheat on *Triticum dicoccum*. His results may be due to the fact that he was working with an immune variety. It is apparent from my results that some varieties are quite susceptible, while others are almost or entirely immune.

My results show two other interesting differences from those of Marchal. In my work, six different varieties of *Triticum durum* were tested. In every case full infection followed. Marchal, on the other hand, states that this species is immune to the wheat

TABLE XXII.—RESULTS WITH *Triticum polonicum* L.

Number of experiment	Date	Source of conidia	Age of plants (days)	No. of plants inoculated	No. of controls	Results		
						Date	Inoc. plants	Controls
71a	1908 Feb. 10	*Triticum dicoccum*	9	2	1	1908 Feb. 17	+++	—
59c	" 1	*Triticum durum*	8	3	2	" 10	+++	—
73c	" 10	*Triticum polonicum*	9	1	1	" 17	+++	—
57a	" 1	*Triticum Spelta*	8	3	1	" 10	+++	—
51a	Jan. 24	*Triticum vulgare*	10	3	2	Jan. 30	+++	—
52c	" 24	" "	10	3	2	" 30	+++	—
53b	" 24	" "	10	3	1	" 30	+++	—
62c	Feb. 3	" "	10	2	0	Feb. 10	+++	..
75b	" 10	" "	9	1	0	" 17	+++	..
92a	" 22	" "	9	3	3	" 29	+++	—
168c	Nov. 20	" "	6	3	4	Nov. 26	+++	—
169c	" 20	" "	6	3	2	" 26	+++	—

TABLE XXIII.—RESULTS WITH *Triticum Spelta* L.[1]

Number of experiment	Date	Source of conidia	Age of plants (days)	No. of plants inoculated	No. of controls	Results		
						Date	Inoc. plants	Controls
72c	1908 Feb. 10	*Triticum dicoccum*	9	2	2	1908 Feb. 17	+++	—
59a	" 1	*Triticum durum*	8	4	6	" 10	+++	—
83b	" 21	" "	8	3	3	" 29	+++	—
84b	" 21	" "	8	4	4	" 29	+++	—
61c	" 1	*Triticum polonicum*	8	2	4	" 10	+++	—
74b	" 10	" "	9	3	1	" 17	+++	—
56c	" 1	*Triticum Spelta*	8	4	7	" 10	+++	—
69b	" 10	" "	9	3	3	" 17	+++	—
49c	Jan. 24	*Triticum vulgare*	10	3	2	Jan. 30	+++	—
54c	" 24	" "	10	3	3	" 30	+++	—
55b	" 24	" "	10	3	3	" 30	+++	—
89a	Feb. 22	" "	9	6	3	Feb. 29	+++	—
102c	May 16	" "	10	4[2]	3	May 24	+++	—
103b	" 16	" "	10	2[2]	2	" 24	+++	—
110c	July 7	" "	4	3	2	July 14	+++	—
134c	Oct. 21	" "	8	6	3	Oct. 30	+++	—
139c	" 31	" "	7	3	5	Nov. 7	+++	—
142a	" 31	" "	7	5	5	" 7	+++	—

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[1] *Triticum sativum Spelta* Hackel.

[2] Two leaves of each plant inoculated.

mildew. The other case is with reference to *Triticum monococcum*, which Marchal claims gave negative results. As already stated, forty-seven out of fifty-seven leaves inoculated became infected in the tests which I made.

It is evident from this review that the mildew on each of the

TABLE XXIV.—RESULTS WITH *Triticum Thaoudar* Boiss.

Number of experiment	Date	Source of conidia	Age of plants (days)	No. of plants inoculated	No. of controls	Results		
						Date	Inoc. plants	Controls
	1908					1908		
125a	July 28	*Triticum vulgare*	4	4	4	Aug 5	+++	—
127b	Oct. 19	" "	6	4	2	Oct. 26	+++	—
145a	" 31	" "	7	4	2	Nov. 7	+++	—
148a	Nov. 2	" "	9	6	2	" 7	+++	—
154a	" 10	" "	7	2	1	" 19	+++	—
160a	" 12	" "	9	4	2	" 20	+++	—

TABLE XXV.—RESULTS WITH *Triticum Tumonia* Schrad.

Number of experiment	Date	Source of conidia	Age of plants (days)	No. of plants inoculated	No. of controls	Results		
						Date	Inoc. plants	Controls
	1908					1908		
124b	July 28	*Triticum vulgare*	4	3	2	Aug. 5	+++	—
134a	Oct. 21	" "	8	1	0	Oct. 30	+++	....
155a	Nov. 10	" "	7	2	0	Nov. 19	+++	....
161a	" 12	" "	9	3	1	" 21	+++	—

TABLE XXVI.—RESULTS WITH *Triticum turgidum* L.[1]

Number of experiment	Date	Source of conidia	Age of plants (days)	No. of plants inoculated	No. of controls	Results		
						Date	Inoc. plants	Controls
	1908					1908		
113a	July 14	*Triticum vulgare*	4	4	2	July 21	+++	—
114b	" 14	" "	4	2	1	" 21	+++	—
117b	" 22	" "	5	1	0	" 29	+++	...
124c	" 28	" "	4	2	2	Aug. 5	+++	—
126b	" 28	" "	4	3	2	" 5	+++	—
134b	Oct. 21	" "	8	2[2]	1	Oct. 30	+++	—
165c	Nov. 20	" "	6	3	2	Nov. 26	+++	—
167a	" 20	" "	6	3	2	" 26	+++	—
168a	" 20	" "	6	3	3	" 26	+++	—

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[1] *Triticum sativum turgidum* Hackel.

[2] Two leaves of each plant inoculated.

four cereals is restricted to the species of each genus. The mildew on oats occurs on species of *Avena* only; the barley mildew on species of *Hordeum* only; the rye mildew on species of *Secale* only; and the wheat mildew on species of *Triticum* only.

TABLE XXVII. — RESULTS WITH *Triticum vulgare* Vill.[1]

Number of experiment	Date	Source of conidia	Age of plants (days)	No. of plants inoculated	No. of controls	Results		
						Date	Inoc. plants	Controls
10b	1907 Dec. 24	*Hordeum vulgare*	10	3	3	1907 Dec. 30	—	—
10c	“ 24	“ “	10	3	3	“ 30	—	—
11a	“ 24	“ “	10	5	4	“ 30	—	—
11c	“ 24	“ “	10	2	4	“ 30	—	—
12c	“ 24	“ “	10	2	2	“ 30	—	—
14a	“ 25	“ “	11	4	5	“ 30	—	—
15b	“ 25	“ “	11	3	4	“ 30	—	—
20a	“ 31	“ “	10	4	4	1908 Jan. 7	—	—
22b	“ 31	“ “	10	2	2	“ 7	—	—
36a	1908 Jan. 2	“ “	8	3	3	“ 11	—	+[2]
37a	“ 2	“ “	8	3	3	“ 11	—	—
47c	“ 18	“ “	14	2	3	“ 24	—	—
112b	July 10	“ “	7	6	6	July 18	—	—
98a	Mar. 3	*Hordeum Zeocriton*	7	3	2	Mar. 10	—	—
100a	“ 3	“ “	7	2	1	“ 10	—	—
101b	“ 3	“ “	7	3	3	“ 10	—	—
114a	July 14	*Triticum compactum*	4	3	3	July 22	+++	—
39b	Jan. 17	*Triticum dicoccum*	13	3	4	Jan. 24	+++	—
40a	“ 17	“ “	13	3	3	“ 24	+++	—
71b	Feb. 10	“ “	9	3	3	Feb. 17	+++	—
72b	“ 10	“ “	9	2	2	“ 17	+++	—
58c	“ 1	*Triticum durum*	8	2	3	“ 10	+++	—
60b	“ 1	*Triticum polonicum*	8	2	2	“ 10	+++	—
61a	“ 1	“ “	8	2	1	“ 10	+++	—
73a	“ 10	“ “	9	3	1	“ 17	+++	—
57c	“ 1	*Triticum Spelta*	8	1	1	“ 10	+++	—
70c	“ 10	“ “	9	2	2	“ 17	+++	—
16a	1907 Dec. 25	*Triticum vulgare*	11	3	3	1907 Dec. 30	+++	—
17c	“ 25	“ “	11	2	6	“ 30	+++	—
18b	“ 25	“ “	11	3	5	“ 30	+++	—
19b	“ 25	“ “	9	3	4	“ 30	+++	—
26a	“ 31	“ “	10	2	2	1908 Jan. 7	+++	—
27c	“ 31	“ “	10	2	3	“ 7	+++	—
28c	“ 31	“ “	10	1	1	“ 7	+++	—
29b	“ 31	“ “	10	3	3	“ 7	+++	—
30b	1908 Jan. 2	“ “	8	3	2	“ 11	+++	—
31c	“ 2	“ “	8	2	2	“ 11	+++	—
32c	“ 2	“ “	8	3	2	“ 11	+++	—
33c	“ 2	“ “	8	3	3	“ 11	+++	—
41a	“ 17	“ “	13	2	2	“ 24	+++	—
42c	“ 17	“ “	13	3	3	“ 24	+++	—
43b	“ 17	“ “	13	3	3	“ 24	+++	—
49a	“ 24	“ “	10	3	2	“ 30	+++	—
50a	“ 24	“ “	10	3	1	“ 30	+++	—
51c	“ 24	“ “	10	3	2	“ 30	+++	—
52b	“ 24	“ “	10	2	3	“ 30	+++	—
53c	“ 24	“ “	10	3	2	“ 30	+++	—

TABLE XXVII. — RESULTS WITH *Triticum vulgare* Vill.[1]—*Continued.*

Number of experiment	Date	Source of conidia	Age of plants (days)	No. of plants inoculated	No. of controls	Results		
						Date	Inoc. plants	Controls
	1908					1908		
54b	Jan. 24	*Triticum vulgare*	10	3	2	Jan. 30	+++	—
55c	“ 24	“ “	10	3	1	“ 30	+++	—
63b	Feb. 3	“ “	10	2	1	Feb. 10	+++	—
75c	“ 10	“ “	9	2	3	“ 17	+++	—
76c	“ 10	“ “	9	4	2	“ 17	+++	—
90c	“ 22	“ “	11	3	3	“ 29	+++	—
92b	“ 22	“ “	11	4	4	“ 29	+++	—
97c	Mar. 3	“ “	7	3	3	Mar. 10	+++	—
102a	May 16	“ “	10	2[3]	2	May 24	+++	—
103a	“ 16	“ “	10	2[3]	1	“ 24	+++	—
104a	“ 30	“ “	6	2	2	June 10	+++	—
105a	June 24	“ “	4	3	3	“ 30	+++	—
106a	“ 24	“ “	4	4	3	“ 30	+++	—
107a	“ 24	“ “	4	2	2	“ 30	+++	—
109a	July 7	“ “	4	3	2	July 14	+++	—
113b	“ 14	“ “	4	3	4	“ 22	+++	—
117b	“ 22	“ “	5	1	0	“ 29	+++	....
118c	“ 22	“ “	5	3	2	“ 29	+++	—
122a	“ 28	“ “	4	3	2	Aug. 5	+++	—
123b	“ 28	“ “	4	3	2	“ 5	+++	—
124a	“ 28	“ “	4	3	5	“ 5	+++	—
125b	“ 28	“ “	4	2	3	“ 5	+++	—
126c	“ 28	“ “	4	2	3	“ 5	+++	—
127a	Oct. 19	“ “	6	2	2	Oct. 26	+++	—
128c	“ 19	“ “	6	2	2	“ 26	+++	—
129a	“ 19	“ “	6	3	1	“ 26	+++	—
141b	“ 31	“ “	7	3	3	Nov. 7	+++	—
143b	“ 31	“ “	7	4	3	“ 7	+++	—
148b	Nov. 2	“ “	9	3	6	“ 7	+++	—
154c	“ 10	“ “	7	2	1	“ 19	+++	—
157a	“ 10	“ “	7	2	2	“ 19	+++	—
160c	“ 12	“ “	9	6	3	“ 20	+++	—
162a	“ 12	“ “	9	2	2	“ 21	+++	—
183a	“ 27	“ “	6	5	3	Dec. 5	+++	—
185a	“ 27	“ “	6	4	1	“ 5	+++	—

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[1] *Triticum sativum vulgare* Hackel.

[2] Two small infected areas appeared on one leaf of a control.

[3] Two leaves of each plant inoculated.

So far as tested, all species of *Avena* are susceptible to the oat mildew. All species of *Triticum* are likewise susceptible to the wheat mildew. We find, however, that certain varieties of *Triticum dicoccum* are practically immune to the wheat mildew. Other varieties of this same species are entirely susceptible. Some species of *Hordeum* are immune to the barley mildew, and the same seems to be true of certain species of *Secale* with reference to the rye mildew.

TABLE XXVIII. — GENERAL SUMMARY OF RESULTS WITH THE MILDEWS OF THE CEREALS

Host plant	Conidia from *Avena sativa*		Conidia from *Hordeum vulgare*			Conidia from *Secale cereale*		Conidia from *Triticum vulgare*		
	Marchal	Salmon	Marchal	Salmon	Reed	Marchal	Reed	Marchal	Salmon	Reed
Agropyron repens	—	......	—	......	......	—	......	—	3, 8, 0	......
Alopecurus pratensis	......	1, 4, 0	......	......	......	......	......	......	......	......
Arrhenatherum elatius	+	1, 3, 0	......	......	......	......	......	......	......	......
Avena brevis	.....	2, 5, 5	......	......	......	......	......	......	......	......
" *fatua*	+	......	......	......	......	......	......	......	......	......
" *nuda*	......	1, 3, 3	......	......	......	......	......	......	......	......
" *orientalis*	+	4, 4, 4	.....	......	......	......	......	......	......	......
" *sativa*	+	8, 23, 23	—	1, 3, 0	22^1, 62, 0	—	16, 49, 0	—	3, 11, 0	14^2, 48, 0
" *sterilis*	......	2, 3, 3	......	......	......	......	.....	......	......	......
" *strigosa*	......	2, 4, 4	......	......	......	......	......	......	......	......
Bromus mollis	......	......	.....	......	......	......	5, 12, 0	......	......	......
Dactylis glomerata	......	2, 9, 0	......	......	......	......	8, 16, 0	......	......	......
Festuca elatior	......	......	.....	......	......	......	8, 21, 0	......	......	......
" " *arundinacea*	......	1, 4, 0	......	......	......	......	......	......	......	......
" " *pratensis*	......	1, 4, 0	......	......	......	......	......	......	......	......
" *heterophylla*	......	1, 4, 0	......	......	......	......	8, 42, 0	......	......	......
Glyceria fluitans	.....	......	......	......	......	......	5, 19, 0	......	......	......
Hordeum bulbosum	......	......	—	5, 14, 1	12, 24, 1	......	......	......	......	......
" *decipiens*	......	......	......	5, 15, 15	......	......	......	......	......	......
" *distichon*	......	.....	......	5, 15, 15	25^3, 73, 73	......	......	......	......	2, 5, 0
" *hexastichon*	......	......	+	4, 12, 12	......	......	......	......	......	......
" *intermedium*	......	......	......	1, 3, 3	......	......	......	......	......	......
" *jubatum*	......	......	+	8, 25, 0	6, 17, 0	......	8, 32, 0	......	......	......
" *maritimum*	......	......	—	3, 12, 3	12, 58, 0	......	......	......	......	......
" *murinum*	......	......	+	5, 16, 0	......	......	......	......	......	......
" *nodosum*^{4}	......	......	......	......	13, 64, 51	......	......	......	......	......
" *nudum*	......	......	+	......	19^5, 45, 45	......	......	......	......	2^6, 3, 0
" *secalinum*^{4}	......	......	—	3, 9, 0	......	......	......	......	......	......
" *silvaticum*	......	......	......	4, 12, 0	......	......	......	......	$+^7$	......
" *Steudelii* × *trifurcatum*	......	......	......	......	9, 26, 26	......	......	......	......	......
" *tetrastichon*	......	......	......	.. ...	7, 26, 26	......	......	......	......	......
" *trifurcatum*	......	......	+	......	5, 13, 13	......	......	......	......	......
" *vulgare*	—	1, 6, 0	+	24, 70, 70	49^8, 150, 150	—	15, 45, 0	—	3, 12, 0	18^9, 47, 0

TABLE XXVIII.—GENERAL SUMMARY OF RESULTS WITH THE MILDEWS OF THE CEREALS.—*Continued*

Host-plant	Conidia from *Avena sativa*		Conidia from *Hordeum vulgare*			Conidia from *Secale cereale*		Conidia from *Triticum vulgare*		
	Marchal	Salmon	Marchal	Salmon	Reed	Marchal	Reed	Marchal	Salmon	Reed
Hordeum Zeocriton	......	......	......	3, 9, 9	23[10], 63, 63	......	......	......	......	1, 3, 0
Lolium italicum	......	1, 3, 0	......	......	......	......	......	......	......	......
" *perenne*	......	......	......	......	......	......	9, 39, 0	......	......	......
Phleum pratense	......	1, 4, 0	......	......	......	......	9, 52, 0	......	......	......
Poa annua	......	2, 9, 0	......	......	......	......	......	......	......	......
" *compressa*	......	......	......	......	......	......	5, 16, 0	......	......	......
" *nemoralis*	......	......	......	......	......	......	9, 40, 0	......	......	......
" *pratensis*	......	......	......	......	......	......	12, 75, 0	......	......	......
" *trivialis*	......	......	......	......	......	......	6, 35, 0	......	......	......
Secale anatolicum	......	......	......	......	......	+	......	......	......	......
" *cereale*	—	2, 6, 0	—	1, 3, 0	11[11], 24, 0	+	58, 138, 131	—	2, 8, 0	10[12], 25, 0
" *dalmaticum*	......	......	......	......	......	......	3, 3, 0	......	......	......
" *montanum*	......	......	......	......	......	......	8, 12, 3	......	......	......
" *cereale* × *Triticum vulgare*	......	......	......	......	......	......	13, 18, 9	......	......	10, 16, 1
Trisetum pratense	......	1, 4, 0	......	......	......	......	......	......	......	......
Triticum compactum	......	......	......	......	......	......	......	......	......	9, 32, 32
" *dicoccum*[13]	......	......	......	......	3[14], 9, 0	......	......	......	......	24[15], 75, 75
" *dicoccum*[16]	......	......	......	......	......	......	......	......	......	6, 35, 35
" *dicoccum*[17]	......	......	......	......	......	......	......	......	......	7, 44, 4
" *dicoccum*[18]	......	......	......	......	......	......	......	......	......	6, 27, 0[19]
" *dicoccum*[20]	......	......	......	......	1, 4, 0	......	......	......	......	21[21], 67, 3[22]
" *durum*	......	......	......	......	1, 3, 0	......	......	—	......	25[23], 65, 65
" *Freycenetii*	......	......	......	......	......	......	......	......	......	8, 34, 34
" *monococcum*	......	......	......	......	......	......	......	—	......	23[24], 57, 47
" *polonicum*	......	......	......	......	......	......	......	+	......	12[25], 30, 30
" *Spelta*	......	......	......	......	......	......	......	+	2, 6, 6	18[26], 63, 63
" *Thaoudar*	......	......	......	......	......	......	......	......	......	6, 24, 24
" *Tumonia*	......	......	......	......	......	......	......	......	......	4, 9, 9
" *turgidum*	......	......	......	......	......	......	......	+	......	9, 23, 23
" *vulgare*	—	2, 12, 0	—	1, 3, 0	16[27], 50, 0	—	24, 66, 0	+	5, 19, 19	66[28], 178, 178

[1] Includes five tests, sixteen plants inoculated with conidia from *Hordeum distichon*, and four tests, nine plants inoculated with conidia from *H. Zeocriton*.

[2] Includes one test, three plants inoculated with conidia from *Triticum durum;* one test, five plants inoculated with conidia from *T. polonicum;* and two tests, seven plants inoculated with conidia from *T. Spelta.*

[3] Includes six tests, twenty-three plants inoculated with conidia from *Hordeum distichon;* one test, five plants inoculated with conidia from *H. nudum;* and one test, three plants inoculated with conidia from *H. Zeocriton.*

[4] In the Index Kewensis, *Hordeum nodosum* L. is given as a synonym for *Hordeum secalinum* Schreb. I am uncertain, however, whether Salmon's work was with the same species as the one I tested.

[5] Includes six tests, fourteen plants inoculated with conidia from *Hordeum distichon;* and two tests, six plants inoculated with conidia from *H. nudum.*

[6] Includes one test, one plant inoculated with conidia from *Triticum polonicum.*

[7] Young leaves, when inoculated, became infected.

[8] Includes three tests, ten plants inoculated with conidia from *Hordeum distichon;* one test, one plant inoculated with conidia from *H. nodosum;* one test, four plants inoculated with conidia from *H. nudum;* and five tests, thirteen plants inoculated with conidia from *H. Zeocriton.*

[9] Includes two tests, five plants inoculated with conidia from *Triticum dicoccum;* one test, two plants inoculated with conidia from *T. durum;* one test, two plants inoculated with conidia from *T. polonicum;* and one test, one plant inoculated with conidia from *T. Spelta.*

[10] Includes four tests, sixteen plants inoculated with conidia from *Hordeum distichon;* two tests, seven plants inoculated with conidia from *H. nudum;* and one test, three plants inoculated with conidia from *H. Zeocriton.*

[11] Includes three tests, seven plants inoculated with conidia from *Hordeum distichon.*

[12] Includes one test, three plants inoculated with conidia from *Triticum durum.*

[13] Black Winter Emmer. It may be noted here that Marchal obtained negative results with the wheat mildew on *Triticum dicoccum.* He does not state what variety was used.

[14] Includes one test, two plants inoculated with conidia from *Hordeum Zeocriton.*

[15] Includes two tests, five plants inoculated with conidia from *Triticum dicoccum;* three tests, seven plants inoculated with conidia from *T. polonicum;* and five tests, thirteen plants inoculated with conidia from *T. Spelta.*

[16] Red Emmer.

[17] Common Emmer.

[18] Russian Emmer.

[19] As noted in Table XVIII, exp. 154*b*, one of the plants was plainly not a seedling of the Russian Emmer. This seedling, as already noted, became well infected.

[20] White Emmer.

[21] Includes two tests, six plants inoculated with conidia from *Triticum dicoccum;* two tests, seven plants inoculated with conidia from *T. durum;* and four tests, twelve plants inoculated with conidia from *T. Spelta.*

[22] Discolored areas were observed on inoculated leaves of two plants.

[23] Six different varieties were used. The figures include two tests, four plants inoculated with conidia from *Triticum durum;* three tests, five plants inoculated with conidia from *T. polonicum;* and one test, three plants inoculated with conidia from *T. Spelta.*

[24] Three varieties were used. The results include one test, two plants inoculated with conidia from *Triticum compactum*.

[25] Includes one test, two plants inoculated with conidia from *Triticum dicoccum*; one test, three plants inoculated with conidia from *T. durum*; one test, one plant inoculated with conidia from *T. polonicum*; and one test, three plants inoculated with conidia from *T. Spelta*.

[26] Includes one test, two plants inoculated with conidia from *Triticum dicoccum*; three tests, eleven plants inoculated with conidia from *T. durum*; two tests, five plants inoculated with conidia from *T. polonicum*; and two tests, seven plants inoculated with conidia from *T. Spelta*.

[27] Includes three tests, eight plants inoculated with conidia from *Hordeum Zeocriton*.

[28] Includes one test, three plants inoculated with conidia from *Triticum compactum*; four tests, eleven plants inoculated with conidia from *T. dicoccum*; one test, two plants inoculated with conidia from *T. durum*; three tests, seven plants inoculated with conidia from *T. polonicum*; and two tests, three plants inoculated with conidia from *T. Spelta*.

To these general statements there are two possible exceptions. Marchal states that the oat mildew will infect *Arrhenatherum elatius*. Salmon, however, obtained a negative result with the oat mildew on this grass. The evidence is not conclusive either way. The other exception is that, according to Salmon, conidia from wheat can infect *Hordeum silvaticum*. This species, however, is given in the Index Kewensis as *Elymus europaeus*. Furthermore, only young plants of this grass could be infected with the wheat mildew.

It would seem then that under normal conditions there are well-defined forms of *Erysiphe Graminis* occurring respectively on the species of each of the four cereals.

Especially interesting are the results with the hybrid between rye (*Secale cereale*) and wheat (*Triticum vulgare*). Professor Bubák, from whom I obtained the seed, informs me that the seed came originally from hybrids obtained by Rimpau in Germany.

So far as I can determine, a hybrid between rye and wheat has been obtained by three different workers. Wilson,[30] in 1875, placed rye pollen on the stigma of the wheat flower and thus secured a number of seeds. These seeds gave rise to plants the appearance of whose culm and head was intermediate between rye and wheat. The awns were midway in length between the short, blunt awns of the wheat, and the long, needle-like awns of the rye. The thickness of the culm and the slight villosity below the head were also rye characters. The hybrids were entirely sterile. The anthers did not open; in fact, the pollen was imperfectly developed.

Carman *[10, 11, 12] has also obtained a hybrid between wheat and rye. In 1882 he placed pollen from rye on the stigma of a white club-wheat. From the seed obtained he was able to grow plants for several generations. In the first year there were eight plants, which yielded good grains. The next year the seed from these eight plants was sown and grew to strong, healthy plants, producing, however, a medley of wheat plants. Some had naked heads, others had long awns of various types, all, however, closely related to wheat. The ninth plant obtained in the first year resembled rye and produced apparently worthless grains. However, when these grains were planted, they gave rise to plants which had a strong resemblance to the parent rye. The plants were much taller than the original wheat plant. In the character of the head there was a close resemblance to wheat.

In 1888 Rimpau[23] attempted to cross wheat and rye. He took the pollen from the rye and placed it on the stigma of the wheat flower. He obtained one seed, which gave rise to a plant that had long and narrow awns; the haulms were 30 cm. longer than those of the wheat plants, differing especially in the length and narrowness of the ears from the mother parent. The grains secured from these plants were sown in 1890. One plant produced brown, short, sterile heads similar in form to the square-head wheat; two plants had white, fertile heads, similar to the square-head wheat; the other resembled in character the hybrids of the previous year, having very long, narrow, brown, wheat-like heads, which, however, had the more open flower characteristic of the rye.

As already stated, the seed which I used in my experiments came from this original cross by Rimpau. As seen from TABLE XVI, thirteen tests were made, eighteen plants being inoculated with conidia from the rye. Of these plants, nine showed evidences of infection. Six plants had a fairly good growth of mildew, conidia being produced. On the other three, however, only well-marked discolored areas appeared. In no case did I obtain the vigorous growth of mildew characteristic of this fungus on the rye plant.

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* A good account of Carman's work is given by Barnard.[2]

Sixteen plants of the hybrid were inoculated with conidia from wheat in ten different tests. Of these plants, only one showed any evidence of infection. In experiment 168b, a small patch of mildew with conidia appeared.

In experiments 127c and 127d, different leaves of the same plant were inoculated, one with the rye mildew, the other with the wheat mildew. No infection occurred on either leaf. The same method was followed in experiments 162c and 162d. The leaf inoculated with conidia from rye showed a good growth of mildew, but the leaf inoculated with conidia from wheat gave no evidence whatever of infection.

It is apparent from my previous work that the wheat is entirely immune to the rye mildew. Twenty-four tests were made, in which sixty-six plants were inoculated with rye mildew, not one showing any evidence of infection. In contrast, every one of the one hundred and seventy-eight plants inoculated with wheat mildew, in sixty-six tests, became fully infected. The same thing holds true in the case of rye. Twenty-five rye plants, in ten tests, were inoculated with conidia from the wheat, but not one plant showed any evidence of infection. On the other hand, in a total of one hundred and thirty-eight plants inoculated with rye mildew, in fifty-eight tests, one hundred and thirty-one plants became infected.

The experiments with the rye-wheat hybrid clearly indicate that this hybrid is resistant to both the rye and the wheat mildew. It has, however, proved much more resistant to wheat mildew than to the rye, for only one infection occurred with this mildew. It would be interesting to know the entire history of the hybrid seed experimented with. I do not know to what generation the plants I worked with belonged, nor do I know whether they more closely resemble rye plants or wheat plants. I am growing the plants to maturity in order to determine the latter point.

In this connection it is interesting to mention an experiment by Eriksson[13] on some of Rimpau's rye-wheat hybrids. Eriksson found a form of *Puccinia dispersa* Eriks. & Henn. growing abundantly upon rye-wheat hybrids obtained from Rimpau. He states that the hybrid plants seemed to be more like the wheat than the rye. It is well known that there are two distinct forms of *Puccinia* *dispersa*, the form *Secalis* on rye, and the form *Tritici* on wheat. Eriksson sowed uredospores from the infected hybrid upon three rye plants and also upon three wheat plants of the same age. Eleven days later a rich growth of the rust appeared upon the inoculated areas of the wheat plants. No infection occurred on the rye, although the plants were kept several days longer. It is apparent, then, that this hybrid had a well-marked resistance to the form *Secalis* of *Puccinia dispersa*, and was entirely susceptible to the form *Tritici*.

Some interesting questions are raised by the results obtained with the White Emmer, Russian Emmer, and Common Emmer, and also with the rye-wheat hybrid. These three Emmers are mildew-resistant varieties of *Triticum dicoccum*, two other varieties of this species (Black Winter Emmer and Red Emmer) proving quite susceptible to wheat mildew. The rye-wheat hybrid is the offspring of two parents, both of which are extremely susceptible to a particular mildew and also perfectly resistant to the form specialized on the other plant. The offspring inherits the resistance of both plants, and consequently cannot be fully infected by the fungus specialized on either the rye or the wheat. As has already been stated, the resistance of the hybrid to the wheat mildew is much more marked than is its resistance to the rye mildew.

Considerable interest has recently been manifested in breeding plants resistant to fungus-diseases. In general, two methods have been followed.* The seed of certain individual plants, which had proved able to withstand the attacks of the particular disease, is collected and used as a starting point for securing a disease-resistant variety. The other method has been to cross varieties that have been found to be resistant, with susceptible varieties, in order to combine in one type the resistant characters of the one with the productivity, adaptability for market, etc., of the other.

The first method has been followed by Blinn[5] in developing cantaloups resistant to a blight caused by *Macrosporium cucumerinum* Ellis & Everhart; by Bolley[6] in securing flax resistant to flax wilt (*Fusarium Lini* Bolley); by Bain and Essary[1] in securing red clover resistant to *Colletotrichum Trifolii* Bain; by Jones[17] and others in securing potatoes resistant to late blight (*Phytophthora infestans* de Bary); and by Orton[19] in securing cowpeas resistant to the wilt fungus [*Neocosmospora vasinfecta* (Atk.) E. F. Smith].

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* For a more complete account of these methods, see a paper by the writer in the Second Annual Report of the State Board of Horticulture of Missouri, 284–286. 1909.

A great deal has been done toward securing rust-resistant varieties of wheat and other cereals. For this purpose Carleton[8] has introduced into this country a number of foreign wheats, especially Russian varieties. The common bread wheats, varieties of *Triticum vulgare*, in general are quite susceptible to attacks of rust. On the other hand, many durum wheats, varieties of *Triticum durum*, are relatively immune, the variety Iumillo being almost perfectly resistant. During the season of 1904,[9] the loss of common wheats in large areas of North Dakota, South Dakota, and Minnesota amounted to 50–60 per. cent. of the crop. In the case of the durum wheats, the loss was 10 per cent. or less, generally 3–5 per cent.

Einkorn (*Triticum monococcum*) is also very rust-resistant. Some varieties of Emmer (*Triticum dicoccum*) are resistant, while others are susceptible. The Spelts (*Triticum Spelta*) are quite susceptible to rust attacks.

The second method, that of crossing susceptible and resistant varieties, has also been followed. The wilt disease already mentioned is extremely destructive to watermelons; the citron, however, is resistant. Orton[20] has obtained a hybrid between the watermelon and the citron which is resistant to the wilt. Unfortunately, however, the melons produced on the hybrid vines were not edible. The hybrid was again crossed with the watermelon and plants obtained, one-fourth citron and three-fourths watermelon, very resistant to wilt and also producing good, edible melons.

Attempts have been made to cross resistant varieties of cereals with non-resistant with a fair degree of success. Especially interesting are the results obtained recently by Biffen.[3, 4] He has attempted to show that Mendel's laws of inheritance apply to the transmission of disease-resistant qualities. In 1902 Rivet wheat (*Triticum turgidum*) and Red King (*Triticum vulgare*) were crossed. The former is relatively immune to the attacks of the yellow rust (*Puccinia Glumarum*), while the latter is very susceptible. The hybrids from this cross all rusted very badly, like the parent Red King. However, 300 grains were secured, from which 260 plants were raised in 1903. The season was very favorable for rust. The plants were examined at the height of the rust attack. Sixty-four were found practically immune and one hundred and ninety-five rusted, most of them badly. The ratio of 64 to 195 is nearly 1 to 3. Taken in connection with the fact that the first generation was badly rusted, Biffen concluded that susceptibility and immunity are Mendelian characters, susceptibility being dominant. The results for the third generation confirm this view. An examination of four plots which contained both rusted and non-rusted plants, showed 149 rusted plants and 48 free from rust, a ratio of 3.1 to 1.

Biffen has also crossed American Club Wheat (*Triticum compactum*) and Michigan Bronze (*T. vulgare*). The former is relatively immune, while the latter is a susceptible variety. The hybrids of the first generation were badly rusted. The seed of these hybrids was planted and the following results were obtained:

Plant	5a	yielded	56	rust-free	individuals	and	147	rusted	individuals.
“	5b	“	45	“	“	“	“ 153	“	“
“	5c	“	47	“	“	“	“ 142	“	“
“	5d	“	36	“	“	“	“ 154	“	“
“	5e	“	44	“	“	“	“ 164	“	“
			228				760		

Plants 5f, 5g, 5h, and 5j, gave 295 rust-free plants and 849 rusted. The whole series gave 523 immune and 1,609 rusted, a ratio of 1 to 3.07.

It was observed that the severity of the rust varied on the different plants. From fifty heads of badly rusted plants, .8 gm. of seed was obtained; from fifty heads of moderately rusted plants 64 gm. of seed; and from fifty heads of immune plants, 145 gm. of seed were harvested.

Biffen tested also the inheritance of immunity to the attacks of *Erysiphe Graminis*. *Hordeum spontaneum* Koch and *H. hexastichofurcatum* K.H. were crossed, the former being the immune parent. The hybrid was attacked by mildew as badly as the susceptible parent. In the next generation 56 plants were badly mildewed, 16 slightly attacked, and 7 entirely free. At the same time, the parent *H. spontaneum* was very slightly mildewed, while the other parent was badly attacked.

Biffen concluded that liability to disease is the dominant character, the hybrids of the first generation being quite susceptible to the attacks of the fungus. In the second generation a portion of the hybrids proved practically immune; the remaining ones still proved susceptible to the disease. It is interesting to note that Orton, in his work with the watermelon wilt, found that the hybrid of the first generation was immune.

It must be remembered, of course, that the immunity which plants enjoy against a given fungus is relative, not absolute. Barley plants can be infected with the wheat mildew, if subjected to abnormal treatment. Salmon[26] has mechanically injured barley leaves, subjected them to anaesthetics, alcohol, or water heated to about 50° C., and inoculated them with conidia from wheat. Infection occurred on such treated leaves. Miss Gibson[14] has sown the spores of several rusts on hosts which they are not known to infect. She found that in nearly every case germ tubes were pushed out which passed through the stomata into the mesophyl of the leaf. The parasite may even attain a considerable development in a plant which it finally cannot fully infect.

Plants resistant to a particular fungus in one region may be quite susceptible to the same fungus if transferred to another locality. Butler[7] states that Farrer's hybrids, resistant to rust in Australia, show a marked liability to rust in India. Einkorn in general has been found extremely resistant to rust attacks. Howard,[16] however, reports that in India this same wheat succumbed to the attack of *Puccinia Graminis*, due, probably, to the hot season. The plants remained immune until the hot weather, although surrounded by other wheats infected with rust.

The above-mentioned facts indicate that the external conditions of the plant play a prominent part in determining whether it is immune or susceptible to a given fungus-disease. While immunity or susceptibility to disease may be transmitted from parent to offspring, the influence of external factors must also be taken into consideration.

The study of disease-resistant plants affords an extremely interesting field for investigation. As yet we do not know what immunity is. We are unable to state why Common Emmer is free from the attacks of mildew while the Black Winter Emmer is susceptible, nor do we know to what extent immunity or susceptibility to a given disease can be transmitted from parent to offspring. The influence of external conditions, the factors of a plant's environment, is yet to be worked out. Further investigations with these resistant varieties and their hybrids should throw considerable light on this question.

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